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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN NO. 494 AUGUST, 1934

DIVISION OF AGRONOMY

Growing Cotton Under Irrigation in the Wichita Valley of Texas

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**In cooperation with U. S. Department of Agriculture.
‡In cooperation with Texas Extension Service.
†As of August 1, 1934

The better-staple varieties of cotton, including Delfos, D. P. L. No. 10, Qualla, Ferguson 406, Missdel, and Acala on account of their satisfactory yields and tenderable staple, offer better opportunity for specialized production of cotton of good quality than the shorter-staple varieties under irrigation in the Wichita Valley. During the seven years, 1927 to 1933, Qualla produced an average yield of 404 pounds of lint per acre; Ferguson 406, 403 pounds; D. P. L. No. 10, 397 pounds; Delfos No. 2, 394 pounds; Acala, 380 pounds; and Missdel No. 2, 376 pounds. Half and Half made the largest average yield, 434 pounds of lint per acre, but it has the disadvantage of producing short and untenderable staple.

Commercial fertilizers on the average increased the yield of cotton about 11 per cent, although the increases resulting from individual treatments ranged from 4 to 16 per cent over the yield of cotton on unfertilized soil. While all of the fertilizers increased the yield to some extent, in most cases the increases were not large enough to return a profit above the cost of the fertilizers. The use of barnyard manure in moderate amounts, however, is good farm practice because it produces profitable returns and improves the physical condition of the soil.

Spacing the cotton plants 6 to 24 inches in the row has given the best results. The 6-inch spacing made the largest average yield, 308 pounds of lint per acre, which, however, was probably not siginficantly greater than the yields of the 12-inch, 18-inch, and 24-inch spacings.

In 1932 and 1933 approximately 28 inches of water was required during the growing season for maximum yields of cotton under irrigation in the Wichita Valley. About half of this amount of water occurred as rainfall while the other half was supplied as irrigation water. This amount of water is somewhat higher than the water requirement reported for southwestern Texas.

Root rot is the most destructive disease of cotton under irrigation in the Wichita Valley. It may be controlled to some extent by the use of suitable rotations of fibrous-rooted crops, such as corn, sorghums, and the small grains, in connection with clean cultivation throughout the growing season to keep down weeds which harbor the disease.

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BULLETIN NO. 494 AUGUST, 1934

GROWING COTTON UNDER IRRIGATION IN THE WICHITA VALLEY OF TEXAS

C. H. McDowell

Substation No. 16, Texas Agricultural Experiment Station, is located at Iowa Park in the center of the Wichita Irrigated Valley, 10 miles west of Wichita Falls, Wichita County, 2½ miles southeast of Iowa Park, and approximately 125 miles northwest of Fort Worth. This region is served by the M. K. & T. and Fort Worth and Denver railways, and also by U. S. and State paved highways Nos. 70, 370, and 5 from Wichita Falls to Amarillo. The elevation at the Station is 978 feet above sea level.

This Substation was established in 1924 for the purpose of studying the problems arising in connection with the growing of crops under irrigation in the Wichita Valley. The object of this Bulletin is to report some of the results obtained in growing cotton under irrigation at Iowa Park.

The types of soil in the Wichita Valley are principally Miller sandy and silty clay loams, Yahola fine sandy and silty clay loams, Calumett and Vernon sandy loams. The soil types on the Station consist principally of the Miller and Yahola series. All of the above soil types are suitable for profitable production of cotton and almost all are favorably located for irrigation. Being of alluvial formation, accumulated in ages past by overflows from the Big Wichita River, most of these soils are tight-natured and absorb irrigation water rather slowly, but respond readily to heavy applications of organic matter plowed into the soil from year to year and show a high degree of natural fertility. Deep plowing is essential on these types of soil for breaking up the impervious underlying clay strata, which tend to check penetration of irrigation water into the subsoil. It is important for profitable production of cotton in this valley to have an abundance of subsoil moisture stored up in the soil to a depth of 5 to 6 feet before planting time.

Table 1. Monthly and annual rainfall in inches at the Iowa Park Station

Month	1926	1927	1928	1929	1930	1931	1932	1933	Average
January	1.69	1.78	.72	.42	.95	1.71	3.09	.55	1.36
February	.03	2.54	1.18	1.27	.52	3.97	4.51	.93	1.85
March	2.79	1.43	1.08	3.45	1.46	3.13	.30	4.17	2.23
April	3.85	3.27	2.13	.53	2.62	1.61	1.95	.71	2.08
May	2.29	1.61	3.90	7.30	3.68	2.74	2.11	7.82	3.93
June	3.88	5.45	6.10	1.48	5.13	.77	2.73	.25	3.22
July	7.93	3.27	8.33	4.64	2.69	1.73	3.09	.28	4.00
August	5.66	.95	1.19	.46	1.31	1.06	5.19	5.98	2.73
September	4.06	1.90	.16	4.51	2.13	.59	2.49	.78	2.08
October	3.66	1.33	2.67	1.31	12.14	8.41	1.39	.26	3.90
November	.28	1.31	.85	1.63	1.40	3.24	.15	1.67	1.32
December	5.08	1.29	1.21	.02	2.80	2.34	6.09	2.65	2.69
Total	41.20	26.13	29.52	27.02	36.83	31.12	33.09	26.05	31.39

An abundance of irrigation water is available and consists of floo waters from the vast watershed of the Big Wichita River, impounded i Lake Kemp, located approximately 50 miles west of Wichita Falls. Fro Lake Kemp the water passes through gravity-flow gates, and is brough down the main channel of the Wichita River to Diversion Lake, wher it is held by large dams and check gates. From Diversion Lake, the wate is fed through gravity-flow gates into the main irrigation canals an distributed to the farms of the valley through smaller lateral ditches.

CLIMATIC CONDITIONS

The average annual rainfall at Substation No. 16 for the 8-year period 1926 to 1933, is 31.39 inches (Table 1). The yearly rainfall during thi period has ranged from 41.20 inches in 1926 to 26.05 inches in 1933. Th average annual rainfall for this region is sufficient for profitable productio of cotton, but it is not always favorably distributed during the growin season, as shown in Table 2. Irrigation is, therefore, necessary durin these periods of deficient rainfall, and should be depended upon and use only as a supplement to rainfall. In some years excessive rainfall durin July and August is conducive to heavy infestations of leaf worms, bol worms, and cotton boll weevil, which may result in a low yield of cotton

The average length of the frost-free period for the 8 years is 221 days The shortest frost-free period of 201 days occurred in 1928, while th longest was 236 days, in 1929 and in 1930. The average date of th last killing frost in the spring is April 3, and the average date of the firs killing frost in the fall is November 10. The latest killing frost in th spring was April 22, in 1927 and again in 1931, while the earliest killin frost in the fall was October 24, 1929.

Table 2. Monthly rainfall in inches at Iowa Park Station during the cotton growing season, 1926-33

Year	April	May	June	July	August	September
1926	3.85	2.29	3.88	7.93	5.66	4.06
1927	3.27	1.61	5.27	3.27	.95	1.90
1928	2.13	3.90	6.10	8.33	1.19	.16
1929	.53	7.30	1.48	4.64	.46	4.51
1930	2.62	3.68	5.13	2.69	1.31	2.13
1931	1.61	2.74	.77	1.73	1.06	.59
1932	1.95	2.11	2.73	3.09	5.19	2.49
1933	.71	7.82	.25	.28	5.98	.78
Average	2.08	3.93	3.22	4.00	2.73	2.08

VARIETIES

In the tests with varieties, spacing, fertilizers, and amounts of irriga tion water, rows 3 feet wide and 132 feet long were used. The size o plats ranged from one row (1/110 acre) to five rows (1/22 acre). Ther were two to four plats of each variety or treatment in each test eac year. The average yield of a particular variety or treatment, therefore, is the average of all the plats of that variety or treatment. A general view and arrangement of the field plats at this Station is shown in Figure 1.

Figure 1. General view of the experimental field plats on the irrigated Wichita Valley Experiment Station.

Yields

In order to determine the most suitable varieties of cotton for the irrigated conditions in the Wichita Valley, variety tests were started at the Iowa Park Station soon after it was established. The better-staple varieties, including Delfos, Missdel, Acala, D. P. L. No. 10, Qualla, and Ferguson 406 have produced the highest yields with the exception of Half and Half, and offer better opportunity for specialized production of quality cotton than the shorter-staple varieties. Half and Half made the highest average yield of cotton, but in some years it has the disadvantage of producing short and untenderable staple.

During the seven years of the variety test the yields in pounds of lint per acre of the better-staple varieties, in the order named, were Qualla, 404; Ferguson 406, 403; D. P. L. No. 10, 397; Delfos No. 2, 394; Acala, 308; and Missdel No. 2, 376 pounds (Table 3). The differences in the yield of these varieties are not great, and no doubt any one of them will be quite satisfactory under irrigation in the Wichita Valley.

In order to place all varieties on a comparable basis for the entire seven-year period, percentage ratings were calculated for all varieties, using the eight varieties that had been grown each of the seven years as the "standard," against which the other varieties were compared for the same years. The percentage rating of any variety is obtained by dividing its average yield for the years grown by the average yield of the "standard" for the same years. The average yield of the eight 'standard" varieties for the seven-year period is 330 pounds. The percentage rating multiplied by 330, therefore, gives the comparable yield of lint cotton per acre of each variety tested.

Length of Lint

The length of lint of all varieties grown during the seven years, 1927-1933, is given in Table 4. The classing was done by official and licensed cotton classers of the Department of Textile Engineering, A. & M. College

Table 3. Yield of cotton varieties at Iowa Park Station 1927-33

Variety	Source	Pounds of lint per acre 1927	1928	1929	1930	1931	1932	1933	No. of years grown	Average Pounds Actual	Average Pounds Standard varieties for same period	Average Per-centage rating	Compar-able yield, lbs.
Half and Half	B. F. Summerour, Norcross, Ga.		302	158	574	384	741	440	6	433	329	131.6	434
Qualla	H. Conrads, San Marcos, Tex.			203	505	308	582		4	400	327	122.3	404
Ferguson No. 406	Ferguson's Seed Farms, Howe, Tex.		316	138	631	279	593	452	6	402	329	122.2	403
D. P. L. No. 10	Delta Pine Land Co., Scott, Miss.					270	735	376	3	460	382	120.4	397
Delfos No. 2	Stoneville Ped. Seed Co., Stoneville, Miss.		279	123	445	328	675		5	370	310	119.4	394
Acala	Walter Watson, Wellington, Tex.	420			519	322	486		4	437	380	115.0	380
Missdel No. 2	Delta Ped. Seed Ass'n., Greenville, Miss.				475	317	555		3	449	394	114.0	376
New Boykin*	Ferguson's Seed Farms, Howe, Tex.	314	264	174	493	274	555	528	7	372	330	112.7	372
Stoneville No. 3	Stoneville Ped. Seed Co., Stoneville, Miss.				449	300	678	359	4	447	401	111.5	368
Delfos No. 6102-531*	Stoneville Ped. Seed Co., Stoneville, Miss.	433	314	122	472	260	579	377	7	365	330	110.6	365
Silvermine	Shaw Plantations, Shreveport, La.					286	512		2	399	362	110.2	364
Kasch	Atwood Cotton Brdg. Farms, Ennis, Tex.					296	490		2	393	362	108.6	358
Westex	Substation No. 8, Lubbock, Tex.					241	542		2	392	362	108.3	357
Stoneville No. 2	Stoneville Ped. Seed Co., Stoneville, Miss.		210	203	434	302			4	287	268	107.1	353
Sunshine	J. W. Davidson and Co., McKinney, Tex.			130	420	277	560		4	347	327	106.1	350
Harper	Robt. M. Harper, Martindale, Texas			145	398	302	535		4	345	327	105.5	348
Acala No. 31	Cotton Branch Exp. Sta., Marianna, Ark.					272	489		2	381	362	105.2	347
Acala*	John D. Rogers, Navasota, Texas	365	207	131	510	319	512	375	7	346	330	104.9	346
Wacona	Lankart-Bred Seed Farms, Waco, Tex.			106	461	243	560		4	343	327	104.9	346
Texas Mammoth	C. N. von Roeder, Knapp, Tex.					273	483		2	378	362	104.4	345
Mebane	A. D. Mebane Estate, Lockhart, Tex.	332	206	124	469	313	443	500	7	341	330	103.3	341
Akroma Acala*	Littlefield Ped. Seed Co., Braden, Okla.	425	248	118	416	244	480		6	322	315	102.2	337
Stoneville No. 1	Stoneville Ped. Seed Co., Stoneville, Miss.		221		405	341			3	322	315	102.2	337
Lone Star*	John Gorham and Son, Waco, Tex.	372	259	148	444	209	484	418	7	333	330	100.9	333
Delfos No. 631-463	Stoneville Ped. Seed Co., Stoneville, Miss.			126	410	245	534		4	329	327	100.6	332
Lankart	Lankart-Bred Seed Farms, Waco, Tex.			92	456	287	471		4	327	327	100.0	330
Cliett Superior	Cliett Cotton Brdg.Farms,San Marcos, Tex.			136	411	268	492		4	327	327	100.0	330
Missdel No. 1	Delta Ped. Seed Ass'n., Greenville, Miss.				372	202	623	362	4	390	401	97.3	321
Kasch*	Ed Kasch, San Marcos, Tex.	294	257	132	506	225	421	404	7	320	330	96.9	320
Hurley Special	H. C. Hurley, Cooper, Tex.					220	480		2	350	362	96.7	319
Missdel No. 3	Delta Ped. Seed Ass'n., Greenville, Miss.						466	378	2	422	450	93.8	310
Hart	J. L. Hart, Chickasha, Okla.					242	398		2	320	362	88.4	292
Greer-WichitaNo.540*	Greer-Staple Brdg. Farms, Iowa Park, Tex.	291	230	97	360	178	482	350	7	284	330	86.1	284
Rowden*	Rowden Bros. and Co., Willis Point, Tex.	302	207	93	399	183	356	419	7	280	330	84.8	280
Missdel No. 4	Delta Ped. Seed Ass'n., Greenville, Miss.						625		1	625			
Acala No. 16-8-1	C. N. Nunn, Porter, Okla.							506	1	506			
LightningExpressNo.8	Coker's Ped. Seed Farms, Hartsville, S. C.							470	1	470			
Startex No. 582	Main Station Farm, College Station, Tex.						469		1	469			
Express No. 121	Delta Ped. Seed Ass'n., Greenville, Miss.						468		1	468			
Acala	Young's Seed Farm, Acala, Tex.						457		1	457			
Mebane No. 4120-141	Substation No. 12, Chillicothe, Tex.							432	1	432			
Wilds No. 3	Delta Ped. Seed Ass'n., Greenville, Miss.						417		1	417			

of Texas. The length showed considerable variation from year to year, but probably not as much as would occur if the cotton had been grown without irrigation.

Table 4. Length of staple of cotton varieties at the Iowa Park Station

(Varieties arranged in order of yields as in Table 3)

Variety	Length of lint expressed in thirty-seconds of an inch								Average length, inches
	1927	1928	1929	1930	1931	1932	1933	Average	
Half and Half	28	28		26	24	28	26	26+	13/16
Qualla				33	33	32		32+	1
Ferguson Triumph No. 406	32	28		30	32	30	31	30+	15/16
D. P. L. No. 10					33	34	32	33	1 1/32
Delfos No. 2				38	38	36		37+	1 5/32
Acala (Watson)	34			34	30	34		33	1 1/32
Missdel No. 2		34		36	36	36		35+	1 3/32
New Boykin	32	28		31	26	30	30	29+	29/32
Stoneville No. 3				37	30	32	33	33	1 1/32
Delfos No. 6102-531		33		36	38	36	34	35+	1 3/32
Silvermine					34	36		35	1 3/32
Kasch (Atwood)					32	31		31+	31/32
Westex					30	30		30	15/16
Stoneville No. 2		30		36	36			34	1 1/16
Sunshine				32	34	31		32+	1
Harper				30	30	32		30+	15/16
Acala No. 31 (Ark.)					33	34		33+	1 1/32
Acala (Rogers)	38	34		34	37	36	36	36	1 1/8
Wacona				34	32	36		34	1 1/16
Texas Mammoth					33	33		33	1 1/32
Mebane (A. D.)	32	32		33	29	32	31	31+	31/32
Akroma Acala		30		33	36	35		33+	1 1/32
Stoneville No. 1		32		34	32			32+	1
Lone Star (Gorham)	33	30		32	32	31	32	31+	31/32
Delfos No. 631-463				38	37	36		37	1 5/32
Lankart				34	32	32		32+	1
Cliett Superior				33	33	30		32	1
Missdel No. 1				37	34	37	36	36	1 1/8
Kasch (Ed)	32	32		32	32	30	31	31+	31/32
Hurley Special					30	31		30+	15/16
Missdel No. 3						36	37	36+	1 1/8
Hart					38	36		37	1 5/32
Greer-Wichita No. 540	38	38		38	38	36	36	37+	1 5/32
Rowden	32	30		31	32	30	32	31+	31/32
Missdel No. 4						36			
Acala No. 16-8-1							34		
Lightning Express No. 8							36		
Startex No. 582						30			
Express No. 121						35			
Acala (Young)						36			
Mebane No. 4120-141							30		
Wilds No. 3		41		40		38		39+	1 7/32

All varieties tested produced tenderable staple, 29/32 inch or longer on the average, except for Half and Half, which produced lint averaging 13/16 inch, which is untenderable and, therefore, undesirable. The longest staple was produced by Wilde No. 3, which averaged 1 7/32 inches for the three years it was grown, although it was one of the lowest-yielding varieties. The longer-staple varieties that were among the highest in yield include Delfos No. 2 and Missdel No. 2, which produced lint 1 5/32 and 1 3/32 inches, respectively. Other high-yielding varieties including Ferguson 406, Qualla, D. P. L. No. 10, and Acala, produced lint ranging in length from 15/16 to 1 1/32 inches. The results of the variety test show that excellent quality of staple may be produced consistently in the Wichita Valley if suitable varieties are grown.

Percentage of Lint

The percentage of lint, or gin turnout, of all varieties tested is shown in Table 5. It ranged from 40.7 for Half and Half, the shortest-staple

Table 5. Percentage of line of cotton varieties at the Iowa Park Station, 1927-33

(Varieties arranged in order of yields as in Table 3)

Variety	Percentage of lint								No. of years grown
	1927	1928	1929	1930	1931	1932	1933	Average	
Half and Half	38.9	40.4	39.5	41.8	43.4	37.3	43.4	40.7	7
Qualla			39.2	36.5	37.1	35.2		37.0	4
Ferguson Triumph No. 406	34.9	34.1	34.6	38.4	36.5	34.0	39.0	35.9	7
D. P. L. No. 10					34.0	33.3	34.0	33.8	3
Delfos No. 2			29.5	29.0	32.1	31.6		30.6	4
Acala (Watson)	33.7			32.5	34.0	32.7		33.2	4
Missdel No. 2		30.1		32.0	31.4	30.2		30.9	4
New Boykin	35.1	33.9	35.9	35.6	34.6	34.2	38.4	35.4	7
Stoneville No. 3				30.4	34.6	33.3	34.6	33.2	4
Delfos No. 6102-531		31.4		32.0	31.4	30.2	32.7	31.5	5
Silvermine					30.2	28.9		29.6	2
Kasch (Atwood)			36.7		39.0	36.5		37.4	3
Westex					30.8	30.2		30.5	2
Stoneville No. 2		33.3	33.3	31.9	32.7			32.8	4
Sunshine			33.3	33.1	33.3	32.7		33.1	4
Harper			38.1	38.1	39.6	34.0		37.5	4
Acala No. 31 (Ark.)					34.6	32.1		33.4	2
Acala (Rogers)	31.9	31.5	31.2	32.2	36.5	32.9	37.1	33.3	7
Wacona			34.4	33.8	34.0	33.3		33.9	4
Texas Mammoth					34.6	32.7		33.7	2
Mebane (A. D.)	37.5	37.6	37.2	37.7	39.6	36.1	39.6	37.9	7
Akroma Acala		33.2		33.3	34.0	32.9		33.4	4
Stoneville No. 1		33.6		31.3	33.3			32.7	3
Lone Star (Gorham)	36.6	37.9	37.0	34.6	35.2	32.9	37.1	35.9	7
Delfos No. 631-463				31.0	31.4	30.2		30.9	3
Lankart			36.4	38.2	39.6	36.1		37.6	4
Cliett Superior			38.5	37.1	37.7	35.8		37.3	4
Missdel No. 1				31.4	31.4	30.8	32.7	31.6	4
Kasch (Ed)	37.6	39.1	38.5	37.5	39.6	36.5	40.3	38.4	7
Hurley Special					34.0	33.5		33.8	2
Missdel No. 3						30.6	31.4	31.0	2
Hart					31.4	30.8		31.1	2
Greer-Wichita No. 540	30.8	29.7	30.1	31.8	28.3	31.4	32.7	30.7	7
Rowden	32.6	32.9	31.6	34.8	33.3	31.4	35.2	33.1	7
Missdel No. 4						32.1			
Acala No. 16-8-1							35.8		
Lightning Express No. 8							30.2		
Startex No. 582						32.9			
Express No. 121						30.2			
Acala (Young)						34.6			
Mebane No. 4120-141							39.6		
Wilds No. 3		30.7	31.7	31.9		30.2		31.1	4

variety, to 29.6 for Silvermine, one of the longest-staple varieties. The high-yielding, better-staple varieties, such as Delfos No. 2, Missdel No. 2, Acala, D. P. L. No. 10, Ferguson 406, and Qualla, had average percentages of lint of 30.6, 30.9, 33.2, 33.8, 35.9, and 37.0, respectively. In selecting a variety of cotton to plant too much emphasis should not be placed on percentage of lint for the reason that high percentage of lint is frequently associated with short staple. This is particularly true in the case of Half and Half, which had the highest percentage of lint and the shortest

PREPARATION OF THE LAND

Plowing and Leveling

In general, the land utilized on the Station for cotton production is under a definite system of crop rotation, in which the preceding crops are fibrous-rooted, such as corn, grain sorghums, small grain, or hay crops of Sudan grass and sumac sorghum. In this system of rotation, cotton never follows cotton, alfalfa, or other leguminous crops that are susceptible to attacks of cotton root-rot disease. Where cotton followed small grains, corn, grain sorghums, or Sudan grass and sorgo for hay, the land was plowed 6 to 7 inches deep with a mold-board plow, turning under all stalks and vegetable growth on the land. The plowing was done as early as possible after these crops were harvested. Before plowing, all stalks were chopped down with a single-row stalk cutter, then double-disked and plowed under. The land was allowed to lie in the rough until early spring, when it was double-disked, harrowed, and leveled for irrigation with a heavy four-horse land drag or float. This leveling each year is necessary to fill up all dead furrows and turning furrows, and to level down all ridges and back furrows, before the land can be satisfactorily irrigated. It is necessary that the field be leveled so that the greatest slope will be in the direction the rows are to run, with the least side slope possible. Where the side slope is too great the field is bordered up at regular intervals varying from 10 to 20 or more rows between the borders to obtain blocks that will irrigate evenly throughout. The proper slope with the rows should not exceed 1 inch per 100 feet.

Where cotton followed small grain on land that was leveled and bordered up the year previous, good results were secured by double-disking the stubble immediately after harvest, followed by listing and re-listing, care being given not to destroy the borders already established.

Seed Bed Preparation and Pre-Irrigation

Soon after the land is leveled, it is marked off with a 3-row marker with rows 36 inches apart and bedded up lightly with a walking middle buster or with a disk cultivator. This bedding is completed early in March and the beds allowed to settle and take up all the rainfall possible before planting. When rainfall is deficient during March and April, it becomes necessary to pre-irrigate the cotton land before planting. This can best be done before any attempt is made to harrow or drag down the beds, as the deep water furrows as well as the high beds allow the irrigation water to completley fill the furrows, and hold the water in check until it has soaked through the beds and penetrated deep into the soil.

Pre-irrigation should be heavy enough to allow moisture penetration to a depth of 4 or 5 feet. On the heavy types of soil, 2 to 3 acre-inches of irrigation water is required to penetrate to the desired depth. If there is any doubt about there being sufficient moisture to germinate cotton seed, it is much safer to delay planting long enough to pre-irrigate, than to rush the planting and afterward attempt to "irrigate the cotton up". This practice of "irrigating cotton up" usually results in poor germination and uneven stands. To delay pre-irrigation, hoping it will rain, or because rain is predicted, is often a costly experience to the cotton grower. The safest practice is to pre-irrigate the seed bed whenever there is a lack of moisture to germinate the seed, and to keep the young plant growing several weeks after emergence, whether it rains the next day after the irrigation or a week later. All the damage a rain can do at this time is to delay cotton planting a week or ten days donger.

When sufficient moisture is present in the seed bed, the beds are harrowed with a spike tooth harrow or light drag to almost level just before planting.

FERTILIZERS

The use of various kinds and amounts of fertilizers has increased the yield of cotton under irrigation at the Experiment Station, but probably not enough to make the practice profitable. In the fertilizer work shown in

Table 6. Yield of cotton in fertilizer experiment at Iowa Park Station, 1929-33

Fertilizer treatment		Pounds of lint per acre						Rank	Percentage increase produced by fertilizer
Kind	Pounds per acre	1929	1930	1931	1932	1933	Average		
Manure	16000	248	256	415	461	401	356	1	16.0
Manure	24000	229	262	359	417	380	329	13	7.2
Manure and 18% superphosphate	24000 400	303	250	365	407	383	342	9	11.4
8-12-4	400	195	245	369	421	484	343	8	11.7
6-12-4	400	213	250	396	451	431	348	6	13.4
4-12-4	400	238	251	359	447	386	336	11	9.5
4-12-4*	400	224	290	404	405	423	349	5	13.7
0-12-4	400	177	227	365	430	408	321	14	4.6
4-12-4	400	238	251	359	447	386	336	11	9.5
4-8-4	400	192	279	384	448	429	346	7	12.7
4-6-4	400	206	262	361	447	425	340	10	10.8
4-0-4	400	190	247	305	446	410	320	15	4.2
4-12-8	400	195	202	371	439	395	320	15	4.2
4-12-4	400	238	251	359	447	386	336	11	9.5
4-12-0	400	177	233	407	480	381	336	11	9.5
8-12-8	800	248	250	360	471	423	350	4	14.0
4-12-4	800	261	250	392	458	402	353	3	15.0
4-12-4	600	227	245	398	416	378	333	12	8.5
4-12-4	200	258	324	386	413	389	354	2	15.3
No fertilizer		169	222	345	442	356	307	16	

*Cottonseed meal as the source of nitrogen

Table 6 all of the cotton was planted, cultivated, thinned, hoed, and irrigated uniformly. Any differences in yield may be ascribed to the fertilizer treatments.

As shown in Table 6, all of the 17 fertilizer treatments produced larger yields than the unfertilized soil, the increases ranging from 4.2 to 16.0 per cent. The fertilizer treatments as a group increased the yield 10.7 per cent over the yield of the cotton on soil which received no fertilizer. The application of 8 tons of barnyard manure made the highest average yield, 356 pounds of lint per acre, which was 49 pounds, or 16 per cent, more than the yield of the unfertilized soil. Nine other treatments increased the yield 10 per cent or more.

The results indicate that the soil responds to applications of nitrogen and of phosphoric acid but not to applications of potash. For example, the 0-12-4 fertilizer (which contains no nitrogen) made an average yield of 321 pounds of lint per acre, while the 6-12-4 fertilizer (containing 6 per cent of nitrogen) increased the yield to 348 pounds of lint per acre. Likewise, the 4-0-4 fertilizer (which contains no phosphorus acid) produced an average yield of 320 pounds. The addition of 8 per cent of phosphoric acid (the 4-8-4 fertilizer) increased the yield to 346 pounds per acre.

While the use of fertilizers produced some increases in yield, the increases in most cases probably were not large enough to return a good profit, and consequently the use of the commercial fertilizers is not recommended at this time. The use of farm manure in moderate amounts should be good farm practice both because it increases the yield and improves the physical condition of the soil.

PLANTING

Method of Planting

All of the standard cotton planters are satisfactory for planting cotton under irrigation. In the work on the Experiment Station a single row, open feed, riding corn and cotton planter was used with a 16-inch solid sweep attached to push any trash or clods off the beds. A very narrow opening shovel was used and the seed planted 1 to 1½ inches deep on the heavy types of soil. Planting was made about on the level at the rate of approximately 1 bushel of seed per acre. If heavy rains fall soon after planting and before the cotton germinates and emerges, the rows should be scratched lightly in order to break the crust over the seed and to insure easy and full emergence of the tender plants. Failure to break this crust soon after the surface begins to dry often results in poor stands and the possibility of having to plant over again.

Date of Planting

Experiments were conducted in 1931, 1932, and 1933 to determine the best time of planting cotton under irrigation in the Wichita Valley. In 1931 the first two plantings, made on April 20 and May 2, resulted in a failure on account of a killing frost on April 22, followed by cold weather until May 5, as shown in Table 7. The plantings after the middle of June resulted in greatly reduced yields or practical crop failures.

It is evident from these results that high yields of cotton were obtained over a planting period, ranging from April 25 to June 1, a period of 37 days indicating a rather long period in which cotton can be planted for

Table 7. Yield of cotton planted at different dates at Iowa Park Station, 1931-33

Dates planted	Pounds of lint per acre				
	1931	1932	1933	Average 1931-33	Average 1932-33
April 20 to 26	0	897	320	406	609
May 2	0	637	376	338	507
May 15 to 19	311	406	334	351	370
May 31 to June 1		538	404		471
June 16 to 19	241	350	245	279	298
July 3	70				
July 15	12				

satisfactory crop production. With an occasional killing frost occurring as late as April 22, it would not be advisable to plant cotton in the Wichita Valley before this date. It is also evident that the yields are greatly reduced when cotton is planted later than June 15, and when planted later than July 1, a crop failure can be expected, as the crop does not have time to mature before frost.

Use of Delinted and Ordinary Seed

Comparisons were made during 1931, 1932, and 1933 between delinted seed and ordinary seed to determine if any advantage is gained in delinting seed for planting. The seed were delinted by a patented process, known as the Kemgas method, in which dry hydrochloric acid gas is used in removing the fuzz. The fuzzy seed were planted at the rate of 32 pounds to the acre each year and the delinted seed at the rates of 20 pounds to the acre in 1931, 9 pounds in 1932, and 10 pounds in 1933. With both delinted and fuzzy seed the cotton was thinned to a stand of one plant every 12 inches apart in the row.

In two of the three years there was no significant difference between the yield of the delinted and ordinary seed (Table 8). In 1932,

Table 8. The effect on yield of delinting cotton seed for planting

Treatment	Acre yield, pounds lint			
	1931	1932	1933	Average
Delinted	324	564	379	422
Undelinted (fuzzy)	311	637	376	441

however, the ordinary seed made a significantly larger yield than delinted seed. The average yield for the three years was slightly in favor of the ordinary seed although the difference is probably not significant. These preliminary results so far do not indicate that delinted seed have any practical advantages over ordinary, or fuzzy, seed.

CULTIVATION

The first cultivation was given within a few days after planting and consisted of a light harrowing with the teeth of the harrow set half sloping so that the frame of the harrow dragged down the ridges on each side of the row left by the planter sweep. When used in this way, the harrow teeth did not dig out the cotton seed, nor injure the tender plants that were beginning to emerge. During the last few years, cultivations for the first two or three weeks' growth of the cotton was made with harrow-scratchers attached to the feet of a riding cultivator, set at an angle of 30 to 35 degrees to the row with the teeth of the scratcher bar pointing forward. Four cotton middles can be cultivated at one round, and one man and team can cultivate 10 to 15 acres of cotton in a day. The cotton fields were cultivated with this implement after every rain, which prevented heavy crusting of the soil.

When cotton had reached a height of 3 to 4 inches, the first cultivation with sweeps was made, using a riding cultivator, with 6 small sweeps attached, set flat, so that a small amount of soil was rolled just under the cotton plants. Following the first or second cultivation with sweeps, the cotton was thinned to one plant every 12 inches in the row, the cotton at thinning time being usually 4 to 6 inches high. Immediately after thinning, the cotton was cultivated again with the sweeps set to throw more soil around the plants. The cotton was cultivated with sweeps 6 to 8 times during the season, the number of cultivations depending upon the rainfall and the number of irrigations given. As a rule, cultivation followed rainfall and irrigations, and was continued at regular intervals of 10 days to 2 weeks between irrigations and rainfall to the end of the growing season, or until the first bolls had begun to open. After the cotton had begun forming squares, the sweeps were set to throw a little more dirt, each time, toward the cotton, for the purpose of forming higher ridges and deeper furrows to carry larger applications of irrigation water during the fruiting period of the crop, since cotton required more moisture at this growth than at any other time. The higher ridges also prevent irrigation water from standing around the cotton plant and assist in preventing heavy losses from rotting of the lower bolls.

SPACING

The highest yields of cotton may be expected only where there is a good stand of plants on the land. When the Wichita Valley Irrigation Project was constructed there was no specific information indicating the number of plants per acre or the spacing of the plants in the row that might constitute a good stand. On the establishment of the Experiment Station at Iowa Park, work was started to determine the best spacing of cotton plants under irrigation. The cotton was planted in 3-foot rows and thinned to single plants 6, 12, 18, 24, 30, and 36 inches apart in the row.

Table 9. Yield of cotton in spacing experiment at the Iowa Park Station, 1927-33

Inches between plants	No. plants per acre	Pounds of lint per acre								Rank
		1927	1928	1929	1930	1931	1932	1933	Average	
6	29040	74	361	249	226	368	501	375	308	1
12	14520	78	342	210	192	404	428	413	295	3
18	9680	114	330	269	202	345	391	426	297	2
24	7260	117	313	225	213	355	364	451	291	4
30	5830	76	279	265	196	299	336	489	277	5
36	4840	69	273	202	154	261	346	502	258	6

The results of these experiments on the spacing of cotton indicate that spacing the plants 6 to 24 inches in the row resulted in larger yields than wider spacing. During the years 1927 to 1933, however, the closest spacing, 6 inches, made the highest average yield, 308 pounds of lint per acree, as shown in Table 9. There was, however, no significant difference in the average yield of the 6-inch spacing and the yield of the 12-, 18-, and 24-inch spacings. The yields in Table 9 indicate that spacing the plants 30 to 36 inches apart in ordinary rows is too wide a spacing for maximum yields.

These results indicate that spacing plants 6 to 24 inches apart in rows of usual width is safe thinning practice for cotton under irrigation in the Wichita Valley.

IRRIGATING THE CROP

When To Irrigate

With an abundance of subsoil moisture in the soil before planting, resulting from heavy rainfall or from heavy pre-irrigations, cotton should not require further irrigation until it begins to show signs of suffering for lack of moisture. This suffering is indicated by wilting during the hot hours of the day, and the leaves taking on a dark blackish-green color. A vigorous but slow growth of the cotton plant is desired in its early stage of growth, for the purpose of forcing an extensive deep rooting system and to prevent too rank a growth of stalk and vegetative branches. Unless the cotton plants distinctly show the need of additional moisture, no water should be applied until the beginning of the fruiting stage, which occurs during the last of June or the first part of July. After blooming begins, cotton requires more moisture, when irrigations should be the heaviest. A deficiency of moisture at any time during this period usually results in shedding and may stop further fruiting of the plant. The upper leaves of a properly watered cotton plant will be of a fresh looking light-green color, medium-sized, deep-lobed, and of a leathery texture.

The practice of heavy irrigations using 2 to 3 acre-inches with longer intervals apart, has given better results on the Station than frequent light irrigations. A light irrigation on a hot clear day can be compared with a light summer shower, which, as a rule, does more harm than good, and often is the result of heavy losses from shedding, and the moisture is soon lost by rapid evaporation. Heavy irrigations, like heavy summer rains, are lasting and will soak deep into the subsoil and will keep the cotton growing for many days and even weeks during the hottest weather. Heavy irrigations need not be made more often than every 20 to 30 days, which allows more time for good cultivation between irrigations. Experiments as well as good farming practices throughout the irrigated valley indicate that maximum cotton production cannot be made either by neglecting to irrigate during dry periods or by irrigation alone. Frequent cultivations following both rainfall and irrigations reduce the rapid surface evaporation of moisture from the soil and probably favor a deeper rooting of the plants, thus causing them to obtain both plant food and moisture from lower depths of the soil. A deep-rooted cotton plant will grow and withstand the long hot dry periods with less suffering than the shallow-rooted plants.

After the cotton picking season begins, there is no need of further irrigation, as an excess of moisture during harvesting of the crop delays opening of the bolls and causes heavy losses from bolls rotting before opening. No attempt is made to recommend the number of irrigations to give cotton per season, as this varies each year and is governed by the amounts and distribution of rainfall. It is well to keep in mind at all times, that irrigation in the Wichita Valley should be used as a supplement to rainfall, and applied accordingly. It is a costly practice to neglect or delay irriga-

Figure 2. Cotton Irrigation experiments showing mearuring wiers through which all irrigation water is measured accurately to the plats in of acre-inches.

tion of cotton because weather conditions look favorable for rain. If the cotton needs additional moisture, irrigate at once; then if a heavy rain follows, the surplus water should be drained off the fields without delay, and cultivation should be resumed again as soon as the land is dry enough, and continued regularly until the next rain, or until the next irrigation is applied.

Figure 2 shows the method of irrigating cotton and the weirs used to measure accurately the water applied.

Amount of Water Required

The amount of irrigation water required for maximum production of cotton will vary according to the amount and distribution of rainfall. In 1932 experiments were started at Iowa Park to determine the amount of irrigation water required. In this work the total amount of water applied ranged from 2 to 12 inches in 1932, and from 3 to 21 inches in 1933, in addition to the rainfall during the growing season of 13.98 inches in 1932 and 15.11 inches in 1933 (Tablee 10). While the average yield

Table 10. Results from the use of different amounts of irrigation water on cotton at the Iowa Park Station

Total irrigation water applied in acre inches		Total rainfall during growing season, inches		Total irrigation water and rainfall in acre inches			Yield of lint cotton, pounds per acre			Rank
1932	1933	1932	1933	1932	1933	Average	1932	1933	Average	
0	3	13.98	15.11	13.98	18.11	16.04	306	239	273	8
2	7	13.98	15.11	15.98	22.11	19.04	328	344	336	6
0	3	13.98	15.11	13.98	18.11	16.04	337	232	285	7
4	9	13.98	15.11	17.98	24.11	21.04	379	306	343	5
6	12	13.98	15.11	19.98	27.11	23.54	473	339	406	3
8	15	13.98	15.11	21.98	30.11	26.04	428	346	387	4
10	18	13.98	15.11	23.98	33.11	28.54	486	413	450	1
12	21	13.98	15.11	25.98	36.11	31.04	468	385	427	2

of cotton varied considerably, in general, the yield increased as the amount of water, including rainfall and irrigation, was increased to 23.98 inches in 1932 and 33.11 inches in 1933. Further increases in the amount of water caused a reduction in yield during both years. The highest average yield, 450 pounds of lint per acre, resulted from the use of 28.54 inches of water.

Sufficient rainfall occurred during the spring of 1932 to insure an abundance of moisture in the soil to a depth of 5 to 6 feet before planting; therefore, a pre-irrigation was not necessary. The spring of 1933, however, was dry and it was necessary to pre-irrigate with fully 3 acre-inches before planting, to insure an adequate supply of moisture to a depth of 5 to 6 feet. It, therefore, required more irrigation water to produce a maximum yield of cotton for 1933 than was required for 1932. The results of this work for the two years indicate that about 28 inches of water including the rainfall during the growing season is required for the maximum yield of cotton in the Wichita Valley.

COTTON INSECTS

Irrigated cotton in the Wichita Valley is subject to the usual attacks of insects that are prevalent throughout the cotton-growing regions of the South and Southwest. The first insect damage that may occur in any season is from grasshoppers. They have caused considerable damage to fields adjacent to grasslands and waste lands, as well as small-grain and alfalfa fields. The heaviest attacks upon the cotton by grssshoppers, coming from small-grain and alfalfa fields, do not usually occur until after the small grain is harvested and the first cutting of alfalfa for hay is made. Grasshoppers may be controlled by the persistent use of poisoned bran mash, distributed around the edges of the cotton fields next to the stubble, pastures, and alfalfa fields. Excellent control of grasshoppers has been secured on the Experiment Station by the use of grasshopper catchers, equipped with pans holding kerosene oil, with a high screen placed back of the pans for the hoppers to fly against and drop into the pans of oil. This catcher was run over small-grain stubble and alfalfa fields following harvest with good results. The catcher was satisfactorily run over cotton that was not more than 6 to 8 inches high.

Leaf worms may or may not appear, according to the season, and as a rule do not appear until late in the season, following heavy rains during August. Leaf-worm damage is generally considered of minor importance in this region.

Boll weevils, like the leaf worms, may or may not appear in large numbers, according to the season. Heavy rainfall during the months of July and August, following mild winters, is generally favorable for the development of the weevil in sufficient numbers to completely destroy all top crops of cotton that may be set during September and early October.

No concerted effort is made throughout the valley to control infestations of the leaf worm and boll weevil, since heavy crop losses rarely occur from these infestations.

The cotton leaf worm may be readily poisoned by the use of calcium arsenate as a dust or spray, or by the use of Paris green mixed with lime at the rate of 1 pound Paris green to 12 pounds of lime, and dusted on the cotton early in the mornings while the dew is still on the plants.

Dusting, which is the most effective method of controlling boll weevil, is rather impractical in this region because severe weevil infestation is too infrequent to justify the purchase of dusting equipment. The best control method for this region is to practice the early destruction of all cotton stalks before frost each season immediately following the last picking. This can best be done by cutting the stalks with a stalk cutter, then double-disk the field thoroughly, and follow by bedding the stalks under deep or by flat breaking fully 6 inches deep. All weed and grass growth along fence lines, turn rows, and irrigation ditch banks should be destroyed early in September and October, as these places make ideal hibernating quarters for the boll weevil. The early destruction of cotton plants, the food supply of the boll weevil, together with the early destruction of all hibernating quarters, will go a long way in keeping the boll weevil under control.

COTTON DISEASES

The more prevalent diseases of cotton in the Wichita Irrigation Project are cotton root rot, and angular leaf spot or boll rot. These diseases become active following periods of heavy summer rainfall, and usually result in heavy losses to the crop. Such diseases as angular leaf spot, or boll rot, and stem and leaf diseases of cotton are controlled to some extent by the use of seed disinfectants such as Ceresan and by improved methods of delinting the seed.

Cotton root rot, caused by a fungus (*Phymatotrichum omnivorum*), is one of the most destructive cotton diseases known, and is common among the cotton fields throughout this region. Like other fungous diseases, it flourishes in the presence of abundant moisture and high summer temperatures. Under normal dry weather conditions this disease does not appear in this Valley until quite late in the summer, the latter part of July and throughout August and September, and usually a fair yield of cotton is harvested from the dead cotton. If, however, the disease appears early in July, following heavy rain and excessive moisture conditions, the loss is usually very heavy. To prevent the rapid spread of cotton root rot the following control measures are recommended.

Cotton should not follow cotton from year to year, as is the common practice throughout this region. Cotton should not be planted on land on which alfalfa or other susceptible crops, such as the various legumes, or sweet potatoes, okra, beans, cowpeas, beets, and carrots that have died from this disease the previous year. Cotton should be included in a long rotation of 4 to 5 years following such resistant fibrous-rooted crops, as small grain, corn, grain sorghums, Sudan, and such forage crops as sorgo for hay. On fields where as much as 50 per cent of the cotton dies each year, some adapted grain crop should be grown 4 to 5 years continuously before cotton is again planted on the same field. Long rotations with fibrous-rooted resistant crops, deep plowing-under of large amounts of vegetable material each year, followed by clean cultivation of all crops, are all very important in the control of this disease.

There are over 900 kinds of plants now known to be susceptible to cotton root rot, many of which are non-cultivated plants consisting of native weeds and plants found growing in cultivated fields, along fence rows, and waste lands. Among the more common are cockleburs, morning glories, tie vines, pig weeds, rag weeds, sunflowers, thistles, wild vetches, and peas, mallows, ground cherries, and golden rod. The survival of root rot on these weeds, if allowed to grow on the land from year to year, makes it difficult to control root rot by rotation. Therefore, it is important that in any rotation system, clean cultivation should be practiced to such a degree that all weeds and plants will be completely destroyed each year.

For further information on the control of cotton root rot, see Texas Station Bulletin No. 423 of the Texas Agricultural Experiment Station, College Station, Texas.

SUMMARY

Delfos, D. P. L. No. 10, Qualla, Ferguson 406, Missdel, and Acala on account of their satisfactory yield and good quality of staple are the better varieties of cotton for the irrigated conditions in the Wichita Valley.

Fertilizers on the average increased the yield of cotton about 11 per cent, but in most coses the increases were not large enough to return a reasonable profit above the cost of fertilizers. The application of 8 tons of manure produced the largest yield of cotton and has the further advantage of improving the physical condition of the soil.

The results obtained indicate that the cotton plants may be spaced 6 to 24 inches in the row without materially affecting the yield. Wider spacing, however, greatly reduced the yield.

During the two years, 1932 and 1933, an average of about 28 to 30 inches of water, including rainfall and irrigation, was required for maximum yield of cotton. During the two years an average of about 14 inches of rainfall occurred during the growing season, thus leaving the remainder to be supplied as irrigation. Heavy irrigations of 2 to 3 acre-inches applied at longer intervals were better than small applications at more frequent intervals.